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FINAL REPORT

TRANSFERENCE OF ECOLOGICAL CONCEPTS ON A SELF-GUIDED TRAIL

Agreement 16-425-CA
USFS - RM

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Colorado State University

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Associate Professor
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December, 1976

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EXPERIMENT STATION

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SUMMARY

This paper reports on a study designed to determine if trail interpretation transmitting principles of plant and animal ecology was effective in getting people to identify ecological principles in man's social realm. It was developed based upon the environmental education tenet that public awareness, understanding, and commitment are needed for an informed citizenry to guide ecological decision making and social action.

The idea behind the study was to see if concepts of plant and animal ecology could be provided to nature trail users and then translated by the users into human situation analogies. One variation was to provide human situation analogies to the users to see if that test variation produced better transfer of information.

The study area was a trail at Flaming Gorge National Recreation Area. Along the trail were stations keyed to a printed brochure. Each station presented a different ecological principle. Fifteen stations were utilized and it took approximately 45 minutes to walk the trail and read the interpretive messages.

Trail users were divided into three experimental groups: control (no treatment), plant and animal ecology principles, and plant and animal ecology principles plus human ecology analogies. Seventy-one test subjects were in each group. Data were collected from subjects via a multiple choice test with one question for each human ecology analogy. Background data on prior use of the study area and individual subject characteristics were also obtained.

Analysis of covariance was used to evalute the effect of experimental treatments while holding exogenous variables constant. Control was necessary for both age and education.

Results indicate that presentation of plant and animal ecology principles was insufficient to stimulate subject recognition of human situation analogies to the principles. The experimental group which received plant and animal ecology principles via the brochure did not score significantly better or worse than the control (no information) group. On the other hand, the group receiving human ecology analogies in addition to principles of plant and animal ecology did score significantly better on the test than the other two groups.

These results can be viewed from the perspective of transfer learning. Two possible explanations emerge for the negative finding concerning the plant and animal ecology only group. It is possible that this group did not learn the material presented. Or, even if the material was learned, there was no assurance that the subjects could apply it to human situations. To draw the necessary inferences requires higher mental processes than learning the material.

In contrast, the analogy group's better performance can be accounted for in several ways. It is possible that the analogy message provided additional relevant information. This is a distinct possibility since the additional information provided was of the same topic as the test question. Also, it is likely that providing the analogies had an effect on the psychological set of the subjects. That is, they were stimulated to look for and think about ecological parallels in human situations. Finally, the analogy messages may have taught respondents what to look for and actually taught them to transfer the relevant information. This

would have given the analogy groups a decided advantage over the other groups in the test situation.

Whatever the exact reasons for the results, it is apparent that presentation of plant and animal ecology principles was not transferred to human situations by subjects under the conditions of this experiment. Replicating this study plus conducting other similar studies would indicate whether this is a unique or general outcome of nature trail interpretation.

CHAPTER 1

INTRODUCTION

A tenet of environmental education is that ecological awareness, understanding, and commitment are needed for an informed citizenry to guide ecological decision making and social action (Stapp, 1969). To enable this public awareness, understanding, and commitment, it is advanced that the ecological message must be communicated to a vast and varied public consisting of individuals with different life styles, attitudes, and environmental priorities. And it must be advanced in many situations and settings.

Principles of plant and animal ecology have many analogies in man's social realm. It seems reasonable to suggest that greater understanding of these principles and analogies might serve to increase man's propensity to behave as if he were more aware of their implications to his long-term good. Through such understanding might come increased awareness and concern and hopefully greater commitment to ecologically sound behavior at the individual level.

Such increased understanding and concern is related to the missions or functions of the U.S. Forest Service. It is certainly managerially important that recreation area visitors be environmentally aware. Also, many agency-interest group conflicts or disagreements are caused at least in part by misunderstandings.

The U.S. Forest Service holds that man can live in harmony with this land if he is provided with knowledge of his world and the interrelated factors determining his use of it and understands the importance of his role in its future (Jepsen, 1968). For this to be realized man must deal with principles of human ecology. Putney and Wagar (1973) have suggested that alerting visitors to the positive and negative effects of environmental modification by interpreting relationships within the area and contrasting them with an urban setting might be a policy objective in a large planning area such as a national forest. In Sand County Almanac, Aldo Leopold (1949; p. 173) wrote, "To promote perception is the only truly creative part of recreation engineering." Man and his environment is always the starting point (Aldridge, 1974).

However, the persistent problem is how to reach the people so as to influence the way they treat natural resources and their environment. Knowledge and understanding are prerequisites for shaping proper attitudes into an environmental ethic (Ashbaugh, 1970).

Despite these pressing needs and values, little is known about the most effective way of transmitting ecological knowledge to enhance understanding. Even more constraining is the fact that full advantage of the opportunities that do exist is not taken. For example, one common technique is to use recreation area visitor centers and trails to interpret environmental phenomena. While these programs are useful, they tend to be largely descriptive and have generally not attempted to transmit basic principles of plant and animal ecology or to apply these same rules to a human ecology.

Problem

Because of the resources which they control and the contact with publics which they have, recreation agencies should be able to play a significant role in creating ecological awareness, understanding, and commitment among citizens. Yet, recreation agencies often overlook or do not take full advantage of resources available to them to enhance environmental awareness and understanding. For example, a self-guided nature trail can provide an opportunity for communicating principles of ecology to a recreating public while interpreting environmental phenomena of an area. A recreation agency can use the trail for both purposes.

Even if the agency tries to provide the messages, if visitors do not apply principles of plant and animal ecology presented along the trail to the human society, the interpretive experience is incomplete. How effective is trail interpretation in facilitating the identification of principles of ecology analogous to human situations? The purpose of this study was to obtain the answer to this question. We wanted to know if trail users could identify principles of plant and animal ecology and relate them to human situations involving the same ecological tenets.

Objectives

The first objective of this study was to determine if trail interpretation transmitting principles of plant and animal ecology was effective in getting people to identify ecological principles applied to man's social realm. The second objective was to determine if this effectiveness could be facilitated by presenting representative human ecology analogies in addition to the principles of plant and animal ecology transmitted to the trail users.

Hypotheses

Three general hypotheses were generated from these objectives: (1) Given trail interpretation concerning principles of plant and animal ecology, more representative human ecology analogies to these principles will be identified by persons that have walked the trail than by persons who have not yet engaged in the activity; (2) Given trail interpretation about principles of plant and animal ecology plus representative human ecology analogies, more of these analogies will be identified by persons who have walked the trail than by persons who have not yet engaged in the activity; (3) More representative human ecology analogies will be identified by persons who have been given trail interpretation consisting of plant and animal ecological principles plus representative human ecology analogies than by persons who have walked the trail given only plant and animal ecological principles.

The first hypothesis in this set relates directly to the first objective. Data agreement with it would indicate that the trail interpretation had increased the identification of human ecology analogies to principles of plant and animal ecology by trail users. If trail users can identify these principles, it follows that they can better apply these principles to man's social realm. The second hypothesis is necessary to determine if interpretation providing human ecology analogies to the principles of plant and animal ecology is more effective than no interpretation at all. Data agreement with it would indicate that the interpretation did not confuse trail users and increased their ability to identify principles of human ecology. The last hypothesis is concerned with the second objective. Data agreement would indicate interpretation with human ecology analogies is more effective in

getting people to identify and apply these principles to the human situation than is interpretation presenting only principles of plant and animal ecology.

Overview of Study Area

> It is a quiet place for retirement from the roaring waters of the (Red) canyon. . . . between the parks are stately pine forests, half hiding ledges of red sandstone. Mule deer and elk abound; grizzly bears, too, are abundant, and here wildcats, wolverines and mountain lions are at home. The forest aisles are filled with the music of birds, and the parks are decked with flowers. . . . gleaming in the distance are the snow fields, and the mountain tops are away in the clouds.
>
> John Wesley Powell, June 3, 1969
> in The Exploration of the Colorado River and Its Canyons

Thus an intrepid scientist on a daring exploration of the Green River described the land overlooking the Red Canyon. Even before white man's adventures, Ute and Shoshones hunted game and roamed this land. Escalante and Dominiquez were the first known white men to see the majestic High Uintas when they explored the Uinta Basin in 1776. In the early 1800s, trappers searched the area for beaver. William Ashley arranged the first fur-trapping rendezvous of the old West in July of 1825 near the Flaming Gorge.

Indeed, the land was rough and rugged. Many pioneers and ranchers struggled, grubbing sagebrush and digging irrigation ditches, became discouraged and moved on (U.S.F.S. Flaming Gorge vicinity map, 1974). This was the country of Butch Cassidy, the Sundance Kid, and their "Wild Bunch." To these lonely, isolated valleys along the Green River came many fugitives and outlaws, the legend makers of the colorful West (Horan, 1958).

The construction of Flaming Gorge Dam, the establishment of a National Recreation Area, and the building of roads have opened the ageless, legend-scarred land for the people's enjoyment. In 1964, the Bureau of Reclamation completed the dam, impounding the waters of the Green River and creating Flaming Gorge Lake, extending 91 miles to the north amid beautiful hill and canyon backdrops (U.S.B.R. Flaming Gorge pamphlet, 1973). The reservoir and its surrounding land now make up the 200,000 acre Flaming Gorge National Recreation Area, created by Congress in 1968 and managed by the United States Forest Service as a part of the Ashley National Forest (U.S.F.S. Flaming Gorge vicinity map, 1974).

The Red Canyon Visitor Center is located off highway U-44, about 14 miles from the dam visitor center. Gone are the grizzlies, but the rugged mountain forest still speaks of adventure when the winds blow and the sky is crystal-blue. Turkey vultures cruise over the canyon and compete with magpies for carrion. Clark's nutcrackers clatter in the sparkling open grove of ponderosa pines. Bitterbrush patches the forest floor, providing winter forage for plentiful mule deer. Marmots sun themselves on the exposed rock surface that is adorned with colorful lichens. The species inhabiting this region are well adapted to the high elevation, dessicating winds and thin soil layer which characterize this harsh environment.

A self-guiding nature trail, located near the Red Canyon Visitor Center, in the ponderosa pine forest was used as the study site.

Limitations

Time was a major constraint on this study. The trail at Red Canyon took about 45 minutes to walk. Most visitors did not allocate a large

block of time for such an activity. Thus, it was difficult to obtain a large sample, even by sampling all willing trail users. The average time spent filling out the questionnaire was about 20 minutes. This appears to have been only enough time for cursory treatment of the multiple choice questions. In addition, test conditions were not optimal. The blazing sun, frequent high winds, and irksome insects often annoyed respondents, disrupted concentration and prompted them to hurry through the questionnaire.

Another limitation is that this is a case study. The results are specific to this self-guiding trail and interpretive guide and should be very carefully evaluated when generalized to other situations.

Organization of Paper

Methodology--experimental design, study area, procedure, sampling plan, data collection, questionnaire format, and data analysis--is in Chapter 2. Results of the study are given in Chapter 3. The final chapter (4) is a discussion of the results in terms of transfer of learning concepts. Conclusions derived from the study are also presented in the last chapter.

CHAPTER 2

METHODOLOGY

The effects of three treatments were studied. These treatments were: no trail interpretation (X_1), trail interpretation of plant and animal ecological principles (X_2), and trail interpretation of plant and animal ecological principles plus representative human ecology analogies (X_3). The performance (O) of each treatment group on a multiple choice test on which respondents were asked to identify principles of human ecology was measured. All respondents received the same test, regardless of experimental manipulation (X). The Posttest Only Control Group design was used in this study:

Treatment	Test
X_1: control	O: multiple choice test
X_2: plant + animal ecological principles	O: multiple choice test
X_3: X_2 + human ecology analogies	O: multiple choice test

This experimental design was chosen because of its relative economy in subject burden. It has the further advantage of reducing testing sensitization by eliminating the pre-test (Rosenblatt and Miller, 1972). This design controls for, but does not measure the effects of history and maturation (Campbell and Stanley, 1968). However, in this study these are not critical confounding factors because testing of the no analogy group (X_2) and the analogy group (X_3) was conducted immediately after the experimental treatment. The control group was tested before

they walked the trail. Anything that occurred during the time respondents walked the trail is considered part of the interpretive experience and experimental treatment. Since sampling was quota rather than random, a selection bias introducing differences between groups unrelated to the effects of experimental treatment or interacting with treatment effects is possible (Campbell and Stanley, 1968). This possibility was investigated in data analysis and reduced with analysis of covariance.

Study Area

The study area was a foot trail at the Flaming Gorge National Recreation Area on the Ashley National Forest. The trail, approximately one kilometer long, was situated near that recreation area's Red Canyon Visitor Center. Located along the trail, at various intervals, were 15 numbered posts. The trail guide provided an interpretive message corresponding to an ecological principle evident at each of these post stations.

Treatments

The following ecological principles, generalizations or rules of ecology, were identified and explained in the experimental trail guides: energy transfer, habitat, limiting factors, carrying capacity, stability, diversity, niche, web of life, food chain, competition, ecosystem, recycling of resources, predation, and competitive exclusion.

The number of principles presented was determined by the trail design--15 numbered post stations with one principle discussed at each. Selection of principles was guided by two factors. First, the trail

guides and questionnaire were pre-tested on school groups at the Northern Colorado Nature Center in Fort Collins. Those that could be effectively used along the trail at Flaming Gorge were incorporated in the trail guides and questionnaire. In addition, selection was guided by the suitable interpretive resources along the Flaming Gorge trail. Although most ecological principles are relevant to man's social realm, those depicted in the trail guide were most readily exemplified along the study trail.

The ecological principles presented at the post stations were interpreted via a printed brochure with narrative and illustrations. Two brochures were used corresponding to two of the experimental treatments, consistent with the hypotheses. One brochure presented only principles of plant and animal ecology (X_2). This brochure is reproduced in Appendix B. The other trail guide presented principles of plant and animal ecology plus representative human ecology analogies to these same principles (X_3). This brochure is reproduced in Appendix C. The message in each brochure covered the same principle at each station. Presentation of principles for treatment X_3 was identical to that of X_2 except the message was followed by one to three sentences (an average of 24 words) drawing the human ecology analogy. The control group received no ecological interpretation, as specified.

Sampling Plan

Quota sampling was used, and deemed appropriate because the emphasis was on testing for differences between selected types of users, rather than on describing the total user population. A sampling quota

of 210--70 respondents in each treatment group--was considered sufficient for statistical analysis. In order to eliminate sampling bias due to days of the week, weather conditions, holiday visitation and number of encounters, the sampling schedules for the three treatments were rotated. Successive encounters with visitors called for the use of different treatments. The sequence X_1, X_2, X_3, X_1, X_2, X_3, . . . was employed. Visitors walking the trail together were considered an aggregate and always subjected to the same experimental treatment. If an aggregate consisted of more than five members, it was not sampled. Because each time a treatment was administered the sample size could vary from one to five, it was necessary to interview fewer members of each visitor aggregation near the end of the study, as the sampling quota was being reached. In this way, the sampling sequence was maintained, reducing the possibilities of sampling bias, as previously stated. The selection of respondents in aggregates near the end of the experiment was based on the need to gather a sufficient number of observations for each control variable and to equalize the number of respondents in each treatment group. All properly completed questionnaires were included in analysis. Each treatment group contained 71 respondents.

Data Collection

Initial contact with subjects was made as they started the trail. This was done for three reasons. First, the trail is not circular. Trail users had the option of terminating the experience before the end of the trail, where the interviewer would otherwise intercept them. Since very few visitors used the trail each day, it was necessary to

assure contact with every willing volunteer. Secondly, the control group (no interpretation) was administered the questionnaire before they walked the trail. Thus, the interviewer had to be at the trailhead for this condition. The third reason is that only visitors using the trail as a self-guided nature trail were included as subjects in this study. If visitors read the sign explaining that the trail was a self-guiding nature trail and opened the box attached to it which held the trail guides, they were approached by the interviewer. The interviewer asked the visitors if they planned to walk the trail and use the trail guide. If the visitors expressed this intention, they were asked to cooperate with a study by filling out the questionnaire.

Respondents were given the same verbal information, regardless of treatment. They were told that the study was testing different types of brochures and were requested to fill out a questionnaire when they completed the walk. Control respondents were requested to fill out the questionnaire before walking the trail. All were asked to cooperate and told that since so few people walked the trail and over 200 volunteers were needed, their cooperation would be appreciated.

In all cases, subjects were told that there were 15 multiple choice questions concerning human ecology. They were told that if the material looked unfamiliar, they should still read through each question and the possible answers and select the answer they felt was most correct. Respondents were told that since different brochures were used, they might not have had all the information presented in the guide they used. Subjects were assured that the questions were specific and difficult; a perfect score would not be expected of anyone, since then there would be no need for the study.

Subjects were instructed to give only one answer to each question and to work on their own. In one instance, a family collaborated on answers. These forms were discarded. The four times individuals rushed through the interview, circling answers without reading the questions, the forms were considered invalid and omitted from analysis.

When visitors were approached and they refused to cooperate with the study, they were asked the reason for this decision. In this study, five persons said they did not like to fill out questionnaires, eight persons could not read the trail guide and questionnaire because they didn't have their glasses with them, and two people would not fill out a questionnaire because they didn't have time.

Children were asked if they wanted to fill out the questionnaire. Those that felt confident in their ability to read and answer the questions with little difficulty were given the form. When children accepted the form, but could not fill it out, they were asked to assist in the study by completing the questions following the multiple choice concerning age, education level, and so on. They were informed that this information also contributed to the survey. These questionnaires were later discarded.

With the exception of the group receiving no interpretation, interviews were conducted immediately following completion of the trail and return to the trail head. If respondents wished to escape the heat of the sun and the myriad of bugs, they were instructed to complete the questionnaire in the shade or at their vehicles.

Questionnaire Format

Fifteen multiple choice questions asked about principles of human ecology paralleling the ecological principles interpreted about the plant and animal kingdoms in the trail guides. Identification of the principles listed in the Treatment section was tested. The selection of questions used was also guided by a pre-test at the Northern Colorado Nature Center and the suitability of interpretation along the study trail of possible principles to be tested.

Information was also collected on selected subject descriptor variables that were useful for control in analysis. These variables measured included previous experience in the area and on the trail, whether or not the subject read the message at each station, education, sex, age, population of home residence, perceived understanding of ecological concepts and concern about environmental problems.

The questionnaire is reproduced in Appendix A.

Data Analysis

Data were processed on the Colorado State University computer system, utilizing CDC 6400 hardware and the Statistical Package for the Social Sciences (SPSS) software (Nie et al., 1975).

Before proceding with analysis of variance procedures, there was a need to edit the data to determine if any test questions did not discriminate among treatments because of consistently high or low percentage of correct answers across groups. A frequency distribution was calculated for response to each multiple choice question in each treatment group.

Question 10, Which of the following best exemplifies a result of competition?, was not included in the calculation of mean response to the test questions (see Appendix A, Question 10). The proper response, c--creation of slum areas, was answered by only 9.9 percent of the analogy group, 12.7 percent of the no analogy group, and 11.3 percent of the control group. The low score across groups may have been due to the nonspecificity of the term competition. Depending on whether or not the respondent considered inter or intraspecific competition, the question might have been answered differently.

After eliminating Question 10, the testscore was calculated with a correct response to each of the 14 multiple choice questions being weighted equally, one point apiece.

After editing the data, differences in treatment effects as measured by testscore for each treatment group, were estimated by use of the one way analysis of variance fixed effects model. Analysis of variance allows for the simultaneous comparison of many means in order to determine if some statistical relation exists between the experimental and the dependent variables (Hays, 1973). In this study, the experimental variable stands for the qualitatively different treatment administered each group. Under the fixed effects model, inferences are made only among the treatments actually administered (Hays, 1973). In this study, the three treatment groups were the analogy group, no analogy group, and control group.

The mean separation test applied was Tukey's Honestly Significant Difference. When preliminary analysis of variance and F test has shown overall significance, Tukey's HSD is a systematic procedure for comparing

all possible pairs of group means. The groups are divided into homogenous subsets, where the difference in the means of any two groups in a subset is not significant at a prescribed level (Kim and Kohout, 1975). The test was performed at the 0.05 level of significance.

After checking for variation in testscore within treatment groups due to respondent and environmental variables (Appendix D), the process to determine difference due to treatment was refined to eliminate the confounding influences of age and education level. Analysis of covariance was performed designating treatment group as the independent variable with the dependent factor, testscore, and covariates age and education level. Tukey's HSD was the mean separation test used to find which of the three mean testscores differed significantly at the $\alpha \leq 0.05$ level. All data were gathered utilizing multiple choice questions for which respondents were asked to identify a human situation analogy to a principle of ecology.

CHAPTER 3

RESULTS

Data were analyzed to determine if visitors given trail interpretation about plant and animal ecological principles could identify representative principles of human ecology more often than persons receiving no interpretation. Tests were also conducted to see if individuals given trail interpretation concerning plant and animal ecological principles plus representative human ecology analogies could identify more of these same principles applied to the human situation than the no analogy experimental group, as well as the control group (no interpretation).

The one way analysis of variance shown in Table 1 indicated a difference in testscore according to treatment effect significant at the

Table 1. Analysis of variance for Red Canyon self-guided trail study (testscore by treatment group); Flaming Gorge N.R.A., summer, 1975.

Source	d.f.	Sum of Squares	Mean Square	F	Significance Level
Between treatment groups	2	160.48	80.24	9.94	0.01*
Within treatment groups	210	1695.83	8.08		
Total	212	1856.31			

*$p \leq 0.01$

$\alpha \leq 0.05$ level (F ratio = 9.94, 2 df). The subsequent mean separation test, Tukey's Honestly Significant Difference, indicated that the means of the control group (7.07) and the no analogy group (7.19) differ significantly from that of the group receiving analogies (8.97) at the $\alpha \leq 0.05$ level (See Appendix E).

One way analysis of variance of testscores by each environmental or respondent variable indicated that age[1] and education level[2] could be sources of bias confounding differences in testscore attributed to treatment (Appendix D; Tables 2 and 3).

Table 2. Analysis of variance for Red Canyon self-guided trail study (testscore by age); Flaming Gorge N.R.A., summer, 1975.

Source	d.f.	Sum of Squares	Mean Square	F	Significance Level
Between age groups	4	411.04	102.76	14.79	0.01*
Within age groups	208	1445.27	6.95		
Total	212	1856.31			

*$p \leq 0.01$

There was a significant difference at the 0.01 level in testscore by age across treatment groups (F ratio = 14.79, 4 df). Also, within

[1]Ages were grouped into categories as follows: Group 1--15 years and under; Group 2--16-20 years; Group 3--21-30 years; Group 4--31-60 years; and Group 5--over 60 years in age.

[2]Education levels were grouped as follows: Group 1--8th grade or less; Group 2--9th-12th grade education; Group 3--13-16 years of education; and Group 4--17-20 years of education.

Table 3. Analysis of variance for Red Canyon self-guided trail study (testscore by education level); Flaming Gorge N.R.A., summer, 1975.

Source	d.f.	Sum of Squares	Mean Square	F	Significance Level
Between education groups	3	625.91	208.64	36.49	0.01*
Within education groups	205	1172.25	5.72		
Total	208	1798.15			

*$p \leq 0.01$

each treatment group, testscore varied significantly ($\alpha \leq 0.05$) depending on age category (See Appendix F). Regardless of treatment, however, the same mean score of respondents 15 years old or younger was consistently low and the 21-30 years age group always scored highest. Tukey's HSD mean separation test indicated that in the analogy and no analogy group this difference was significant at the $\alpha \leq 0.05$ level.

Disregarding the effect of treatment, there was a significant difference ($\alpha \leq 0.01$) across treatment groups (F ratio = 36.49, 3 df). This is shown in Table 3. Tukey's HSD indicated that respondents with an 8th grade education or less, and those with 9-12 years of schooling had mean testscores that varied significantly at the $\alpha \leq 0.05$ level from those subjects having 13-16 and 17-20 years of education. There was no significant difference between the latter two groups. The one way analysis of variance was then run on each treatment group (See Appendix G). This same general breakdown held within the analogy and no analogy

group. In the control group, the respondents with the least amount of education differed significantly from the two most highly educated groups. In addition, those with a 9th-12th grade education differed significantly ($\alpha \leq 0.05$) from those with higher education.

To adjust for a possible source of bias due to age and education, these variables were entered as covariates in the final analysis of testscore according to treatment group. The adjusted means obtained are considered better estimates of the treatment effects than the unadjusted means because with this procedure a source of experimental error has been removed, and the apparent confounding effects have been controlled (Kim and Kohout, 1975).

The analysis of covariance was run using a fixed effects model. Results are listed in Table 4. Testscore was the dependent criterion

Table 4. Analysis of covariance for Red Canyon self-guided trail study (testscore by treatment group with covariates education level and age); Flaming Gorge N.R.A., summer, 1975.

Source of Variation	Sum of Squares	d.f.	Mean Square	F	Significance Level
Main effects	149.12	2	74.56	14.29	0.01*
Group	149.12	2	74.56	14.29	0.01*
Covariates	584.43	2	292.21	55.99	0.01*
Education level	384.90	1	384.90	73.76	0.01*
Age	5.75	1	5.75	1.10	0.01*
Residual	1064.61	204	5.22		
Total	1798.15	208	8.64		

*$p \leq 0.01$

variable and treatment group was the categorical independent variable or factor. Age and education level were the metric independent variables or covariates. Covariate by factor interaction was assumed to be zero (Kim and Kohout, 1975). Only the main effects along with effects due to covariates were assessed. For this study, only the main effects of variance in testscore due to treatment group are of importance.

Analysis indicated, as shown in Table 4, that the main effects of treatment group on variation in testscore were significant at $\alpha \leq 0.01$ level when the confounding effects of education level and age were controlled. The group receiving interpretation with human ecology analogies averaged 8.81. The mean testscore for the no analogy group was 7.27. The control group averaged 7.15. Tukey's HSD mean separation test indicated that at the $\alpha \leq 0.05$ level, the treatment group supplied with analogies to human ecology scored significantly higher than the no analogy and control groups. There was no significant difference between the no analogy and the control group (See Appendix H).

Considering the results in terms of the three hypotheses, the following evaluation was made:

1. Given trail interpretation concerning principles of plant and animal ecology, representative human ecology analogies to these principles will <u>not</u> be identified more often by persons that have walked the trail than by persons who have not yet engaged in the activity;
2. Given trail interpretation about principles of plant and animal ecology plus representative human ecology analogies, more of these analogies will be identified by persons who

have walked the trail than by persons who have not yet engaged in the activity; and

3. More representative human ecology analogies will be identified by persons who have been given trail interpretation consisting of plant and animal ecological principles plus representative human ecology analogies than by persons who have walked the trail given only plant and animal ecological principles.

CHAPTER 4

DISCUSSION AND CONCLUSIONS

How can one account for the difference in testscore between the analogy and no analogy experimental groups? What does the lack of significant difference in test performance between the control group and no analogy experimental group indicate? In both cases the results can be considered in terms of transfer of learning.

Transfer of learning exists whenever a learning experience or training has influence on the learning or performance of a subsequent task (Blair, et al., 1975). In this study, the information presented in the trail brochure provides the basis of prior training. The subsequent task is the identification of principles of human ecology in choosing the correct responses to the multiple choice questions.

A study of transfer is defined as a two-stage experiment consisting of a training phase and a test phase. The basic question is, how does training in the first stage influence performance during the second phase? In this study, the control group (no interpretation) received no prior training. The two experimental groups (analogy and no analogy) received different degrees of training via the information presented in the two versions of the trail guide. The effects of differences in transference of information through training may be reflected in testscore.

A difference in testscore between the control group and an experimental group would indicate that the experimental treatment had been a source of transfer (Postman, 1971). For any given performance measure, the difference between an experimental group and the control group expresses the amount of transfer in terms of raw score (Postman, 1971). In this study, the number of correct responses on the multiple choice test was used as a measure of transfer. Although it is common practice to translate absolute difference into measures of relative transfer (Gagne, et al., 1948; Murdock, 1957), only absolute measures reflect directly experimental observations and offer unequivocal information (Postman, 1971).

Difference in Testscores Between Analogy and No Analogy Groups

More learning was transferred by the analogy group than the no analogy group, since the former averaged more correct responses on the multiple choice test. Three explanations may contribute to understanding this finding. These are: (1) the provision of additional relevant information to the analogy group; (2) the establishment of a psychological set focusing selective attention on the representative human ecology analogies; and (3) the perception of the human ecology analogies as task directions ("teaching for transfer").

Additional relevant information. That a principle, a rule relating concepts, offers a favorable condition for application under homologous situations is well supported (Hazelrud, 1972). Both experimental groups were provided principles of plant and animal ecology in the training phase of this experiment. However, the analogy group received

additional information--an example of how each principle applied to the human situation.

Studies have shown that the provision of additional relevant information in the training stage can increase understanding and application of the principle in the test task. Earlier experiments (Judd, 1908; Hendrickson and Schroeder, 1941) indicate that verbal knowledge of a principle has a facilitating effect on the degree of transfer evident in an instance requiring application of that principle. Hendrickson and Schroeder (1941) have shown that the amount of transfer was directly related to the amount of information taught. Overing and Travers (1966) confirmed the findings of Judd (1908) and Hendrickson and Schroeder (1941). Considering these experiments, the analogy group may have transferred more learning as a result of the trail interpretive experience because they were provided with additional relevant information--human ecology analogies.

Psychological set. In the same study by Overing and Travers, it was determined that transfer is facilitated by establishing a psychological set relating material to be learned to a practical situation. The analogies to human ecology afforded the higher scoring experimental group do indeed relate information in this manner.

Another way of looking at this same idea is to consider the set as focusing selective attention on representative human ecology analogies. Berlyne (1960) states that an important factor affecting the processes of selective attention is a class of stimulus events he calls indicating stimuli. The establishment of a psychological set may serve to arouse processes of selective attention like those aroused by Berlyne's

indicating stimuli (Overing and Travers, 1966). Thus, the analogy group may focus attention on the human ecology analogies. These pertinent pieces of information which the respondents may focus attention on, may in turn permit the analogy group to process information and respond to multiple choice questions in a manner differently from the no analogy group.

Teaching for transfer. The analogy group may have also processed information on the test differently and answered questions in a different manner because the analogies provided them with cues or clarifying test task directions. A study by Wittrock (1963) implied that under certain conditions meaningful direction can supply distinctive verbal cues which can increase the probability that the learner responds in a directed fashion. The human ecology analogies may have directed this experimental group to think in these terms prior to the test situation, giving them a decided advantage over the no analogy group. When they read the test directions, the analogy group understood them more clearly because they had already been exposed to human ecology analogies. The no analogy group, lacking the selective cues, perceived the test task in a relatively unselected fashion. Indeed, there is some evidence that what is called "teaching for transfer" by Hovland (1951) works well by calling attention in the training phase to other situations in which the learning may be applied. In situations where information provided in training is designed to emphasize transfer by stressing applications, the amount of understanding and useable knowledge increases (Klausmeier, 1969).

Lack of Difference in Testscores Between No Analogy and Control Groups

Findings of this study also indicate that the training provided the experimental group receiving only principles of plant and animal ecology does not influence performance on the multiple choice questions. This no analogy group did not score significantly higher than the control group receiving no interpretation or training prior to taking the test. The relevant information, principles of plant and animal ecology, seemingly was not transferred to the test situation of identifying these same principles when applied to the human situation. Two explanations are offered for this finding. The first is that the material in the test phase was not learned. The second explanation involves the idea that the material was learned, but not applied to the test situation.

Material not learned. In judging a purported failure to transfer, it may be that the material that should have been learned, was in fact not learned (Kelly, 1967). Thus, poor performance on the test task can often by explained by the fact that the information that must be applied to perform well was not adequately learned in the training stage. In regards to transfer of learning, Hilgard et al. (1953) have stated that much of the problem may be in the formulation of the principle. Positive transfer (proactive facilitation) is enhanced when training information is thoroughly learned and well understood. Experiments by Underwood (1951) and Atwater (1953) concluded that performance on the second task increased as the degree of prior learning increased. Travers (1972) confirmed that the more efficient the original learning, the more substantial the transfer. Thus, the no analogy group may not have learned the information concerning principles of plant and animal ecology provided in the trail guide.

Learning of principles is basic to transfer of training. However, from the standpoint of research, it is evident that we have as yet too few experimental results on the most effective ways to use word and symbols to guide the learning of principles (Gagné, 1966). In this study, the analogies to human ecology imparted the higher scoring experimental group may have facilitated the general perception and understanding of basic ecological principles. Hence, when the analogy group was tested they scored highest because they had most effectively learned the principles of ecology in general. The inferences to human situations familiar to the respondents had clarified concept formation and principle learning in the initial stage. The no analogy group, lacking the human ecology analogies, did not learn material necessary to perform well on the test. Thus, they scored no higher than the control group.

Application of learning. Even if the no analogy group had learned the principles presented, this did not assure that they could apply them to human situations. Tyler (1936) concluded that emphasis on the recall of information does not guarantee the higher mental processes of drawing inferences. The no analogy group may have understood the presented ecological principles, but could not infer the connections to human ecological situations on the test. Effective learning of a principle includes being able to use it in similar, applicable situations.

Low Testscores Regardless of Treatment Group

While the analogy group may have learned the principles better or applied them more effectively on the test, regardless of treatment group, overall testscores were low. This may well be attributed to

experimental conditions limiting this study. The test was difficult and required time and concentration. The glare and heat of the sun, the incessant annoyance of insects, and the impatience and excitement of vacationers with many plans undoubtedly contributed to inattention. Considering the length of each station message, the difficulty of the principles and visitor time allocated for the activity, too many principles may have been presented along the trail. The presentation of fewer ecological principles might have increased message retention and performance on the multiple choice test.

Summary

In spite of these less than ideal test conditions, the experimental group receiving analogies to human ecology in the trail guide still scored higher than the no analogy and control group when answering multiple choice questions identifying representative principles of human ecology. This may be due to a combination of factors. Because of differences in training via the trail brochure, the no analogy group may not have learned the information necessary to identify the representative principles of human ecology. It might also be that they learned the principles of plant and animal ecology presented in the trail guide, but were unable to apply them to the identification of human ecological principles without the additional relevant information given the analogy group. This information, in the form of human ecology analogies, may have directed selective attention toward the application of ecological principles to the human situation and increased performance on the test. The analogies may also have clarified the test directions for the higher

scoring group, allowing them to respond to the questions in a more directed fashion, thereby increasing test performance.

In any case, from this study it can be concluded that simple transmission of basic principles of plant and animal ecology via a self-guided trail brochure was ineffective in getting people to identify these same principles when they were applied to man's social realm. However, the identification of these principles was facilitated when the trail users were provided with additional relevant information in the trail guide in the form of human ecology analogies.

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APPENDIX A

QUESTIONNAIRE

QUESTIONNAIRE

Colorado State University
Project 31-1480-5358

The purpose of our study is to see if people can draw human ecology analogies from concepts of plant and animal ecology presented along a nature trail.

By answering the following multiple choice questions you will help us determine how best to design a self-guided trail with this purpose in mind.

1. The only item which man uses that cannot be recycled (is) (are)
   a. nutrients.
   b. tin cans.
   c. plastics.
   d. energy.
   e. all of the above can be recycled.

2. The habitat of an individual is his or her
   a. type of work.
   b. daily routine.
   c. place of residence.
   d. source of income.

3. An example of a limiting factor in a human community is
   a. an anti-pollution device.
   b. a bag limit on the number of fish one can catch in a single season.
   c. a limit on the number of cars one family can own.
   d. the number of jobs available in the community.

4. The human carrying capacity of an area is a measure of the
   a. maximum number of people who can be supported in good health.
   b. diversity of resources used in the community.
   c. maximum amount of food available for human consumption.
   d. degree to which wastes can be recycled back into production.

5. In Community A, almost all the people are employed by oil producing companies. At the present time, oil is in heavy demand.

   In Community B, people are producing a wide variety of different products, all of which are in moderate demand.

   Which of the following is likely to be true?

a. Community A is more stable than Community B.
b. Community B is more stable than Community A.
c. Both communities are equally stable.

6. The types of people found in Commerce City are different from those found in the rural area which surrounds it. A crucial factor in determining the types of people that make up a community is:

a. the amount of energy available in the community.
b. the kinds of resources present in the community.
c. the number of people living in the community.
d. how easily a person can reach the community from surrounding areas.

7. In a human community, the specialized role or occupation of an individual which helps to keep the larger community functioning is referred to as his or her

a. habitat.
b. efficiency factor.
c. niche.
d. web of life.

8. Mr. Brown's bank lends money to Mr. Perry. Mr. Perry uses the money to hire construction workers to build houses. The workers use their wages to buy more goods from local stores. These stores deposit money in Mr. Brown's bank.

What ecological concept is best shown by the above?

a. Creation of a new habitat.
b. Management of ecological systems.
c. Population dynamics.
d. Web of life.

9. It is important for man to protect food chain links of which he is part because

a. an individual depends on all the links below him for food.
b. chains are necessary to bring in the volume of food necessary for the community.
c. it retains competition in the food chain stores.
d. most people now depend on someone else to grow their food.

10. Which of the following <u>best</u> exemplifies a result of competition in society?

a. Creation of new jobs.
b. Diversity in individual activities.
c. Creation of slum areas.
d. Provision of city services.

11. Interacting people and the non-living components of their environment such as buildings, cars and chemical pollutants function together as a human

a. environment.
b. habitat.
c. community.
d. ecosystem.

12. The basic reason we need to recycle our waste products is because

a. as human communities grow, it is becoming more difficult to dispose of the wastes.
b. natural resources are being used up faster than they can be replenished.
c. use of plastics and other non-biodegradable materials upsets the balance of nature.

13. As a predator, man can

a. live in a wide variety of locations, provided there is an adequate food supply to meet his needs.
b. limit and regulate the populations of species he feeds upon.
c. co-exist with species utilizing the same resources he demands.

14. With regard to human population levels

a. steps can be taken to provide needed resources for all people, regardless of number.
b. the population is self-regulating, therefore balance with resources is maintained automatically.
c. forces such as disease, natural disaster and famine are built-in checks which control population levels.

15. A city shows an interest in hockey. Team A, a member of the NHL, and Team B belonging to the WHL, situate in the city.

However, there just aren't enough hockey fans to support both teams. Team A attracts the largest crowds. Team B, nearing bankruptcy, decides it must move to another city or face financial disaster.

This is an example of:

a. community diversity.
b. ecological niche.
c. competitive exclusion.
d. population control.

We have just a few personal and background questions which will give us insight into the answers in Questions 1-15. This information will be strictly confidential and will not be identified with any individual in the analysis.

16. Have you walked this trail before? /__/ Yes /__/ No

17. Have you visited Flaming Gorge before? /__/ Yes /__/ No

18. Did you read the message at each stop? /__/ Yes /__/ No

If NO, why not? _____

_____

19. Please circle the grade level that you have completed.

Primary School	1	2	3	4	5	6	7	8
Secondary School	9	10	11	12				
College	13	14	15	16	17	18	19	+

20. Age _____

21. Sex _____

22. Population of your home residence.

/__/ more than 500,000

/__/ 100,000 - 500,000

/__/ 50,000 - 100,000

/__/ 5,000 - 50,000

/__/ less than 5,000

/__/ rural farm

23. Do you think that you understand ecological concepts

a. very well.
b. better than the average individual.
c. about the same as most people.
d. less than the average person.
e. very poorly.

24. How concerned are you about ecological problems?

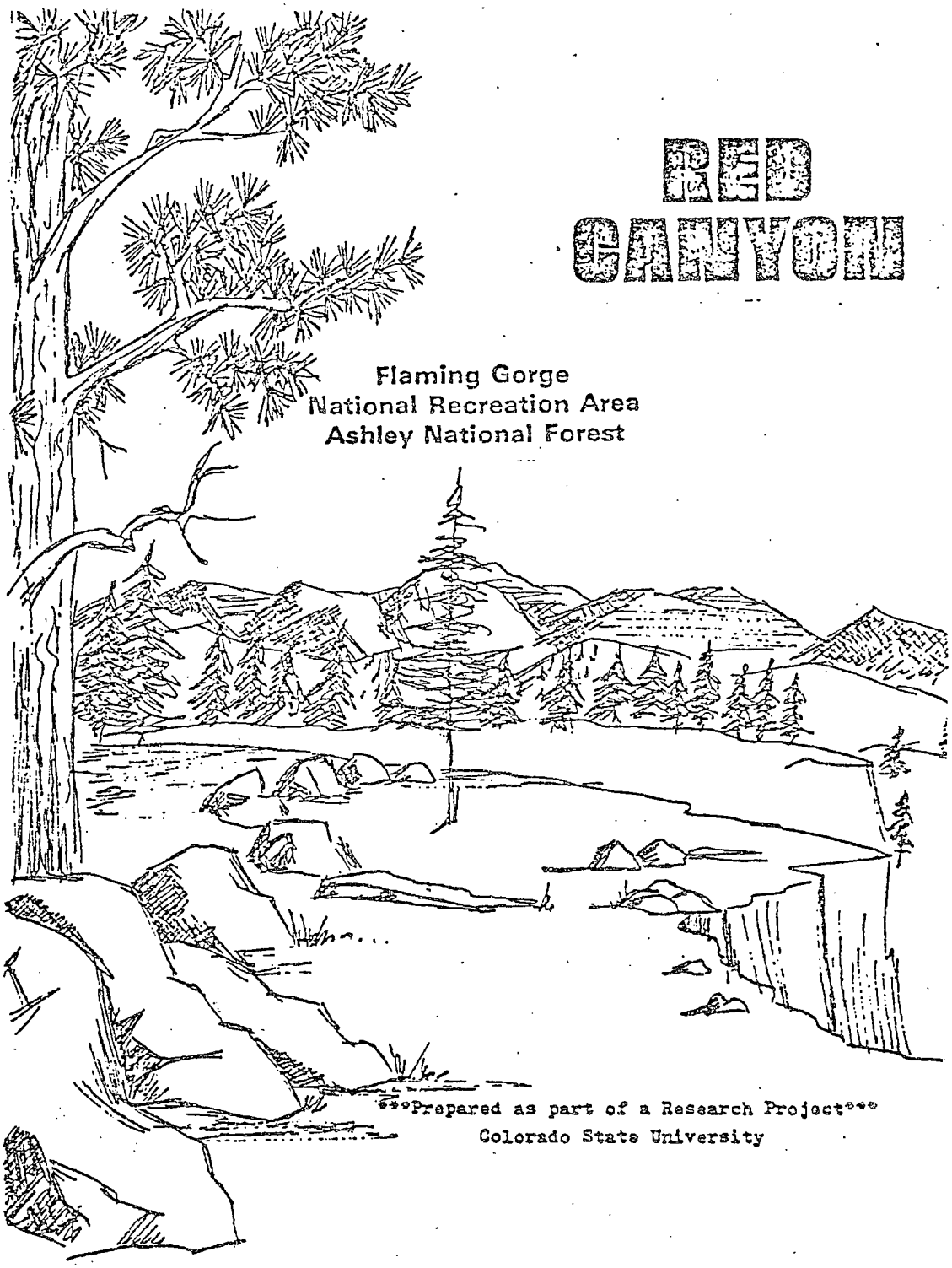
a. extremely concerned.
b. more concerned than most people.
c. as concerned as the general public is.
d. less concerned than most people.
e. not concerned.

_____

*****Thank you for taking time to help us out.*****

APPENDIX B

TRAIL GUIDE WITHOUT ANALOGIES



RED CANYON

Flaming Gorge
National Recreation Area
Ashley National Forest

Prepared as part of a Research Project
Colorado State University

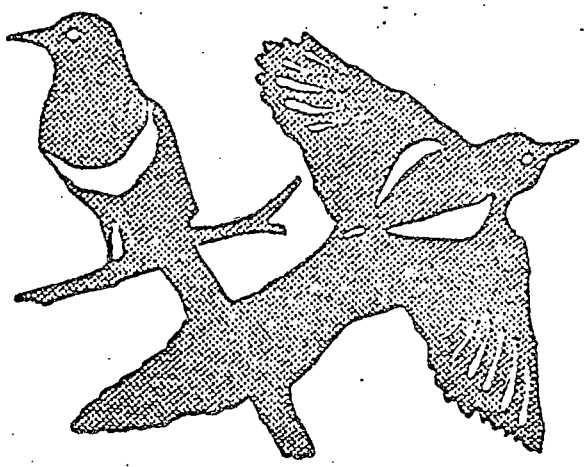
The ponderosa pine, aromatic and sparkling, dominates this community. Dusty-green clumps of bitterbrush can be found below it, providing an important winter food source for mule deer.

Many people who look at this forest see only trees. However, the forest community is a complex association of interacting plant and animal populations. The species in this community demand similar resources. The amount and type of resources such as food, water and living space will determine which forms of life will flourish and which will perish in any region.

Areas with different types of resources will support different types of communities. You could not expect to find the ponderosa growing well in the lush Eastern deciduous forest. Similarly, sugar maples would find this dry region unlivable.

2

Stop and listen. You may hear the songs, chattering or pecking of different kinds of birds. Several species make their homes in the mountain forest. The place where an organism lives is called its habitat. A habitat includes all the features of the environment where a plant or animal lives.

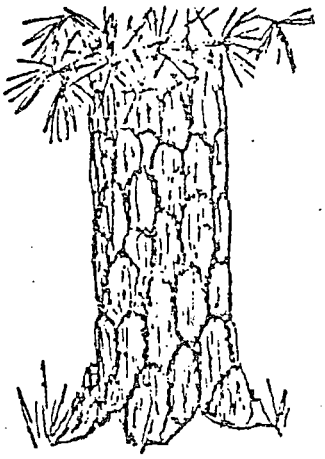


3

Although the wafting fragrance and proud chanty of the pines fill the air, there are many more subtle sounds and smells in this community.

Diversity ensures stability. If this community were composed of nothing but ponderosas, what would happen if all became diseased and died? The forest would become a barren wasteland. The community is stable because other plants reproduce and live here under similar conditions to the pine's. Thus, if all ponderosa pines were eliminated, these other plants could live on the land where the ponderosa once stood. The community could not be easily destroyed.

4



The ponderosa reigns in this small mountain kingdom. The strong trunk and limber branches of this rugged pine make it seem arrogant and independent. However, it is affected by smaller forms of life in the grove, just as they are influenced by this pine.

All living things affect all other living things. The community is made vital by complex interactions. These interactions directly or indirectly tie all its members together in a vast web of life.

When insects destroy a ponderosa pine, its death affects the surrounding life. As the tree is stripped of its foliage more sunlight reaches the forest floor. Different organisms favoring sunlight can now grow there. Those that favored the shade of the pine boughs may now find survival difficult.

5

Mule deer have "highlined" this mountain mahogany by eating everything as high as they could reach. Any new growth that takes place is on the top branches, inaccessible to the browsing animals. Because of this "highlining", this mountain mahogany is out of the deer's food chain.

A food chain is simply a series of plants and animals which are eating and being eaten. No matter how long the chain may be it begins with green plants or producers and ends with decomposers, the organisms of decay. The links between producers and decomposers depend on the community.

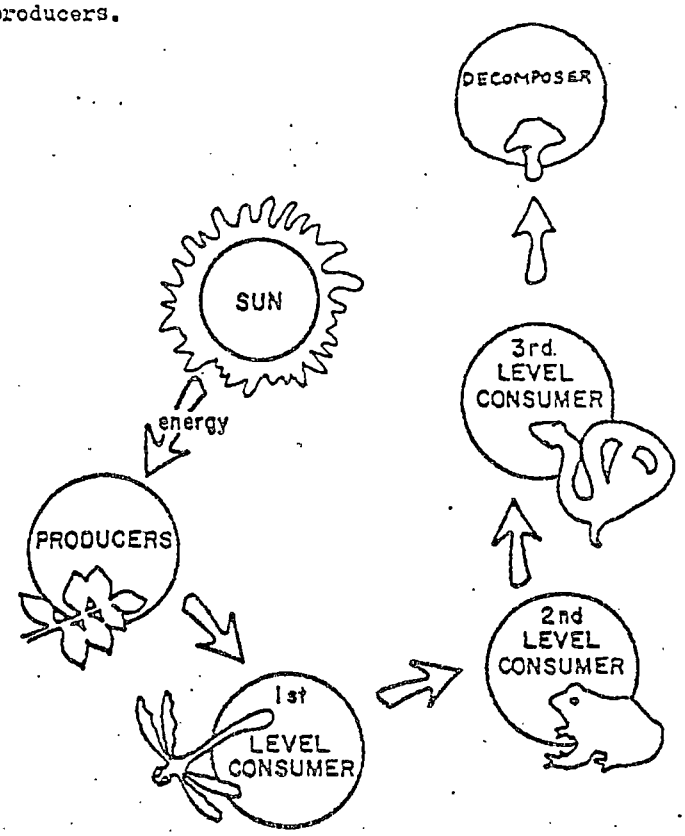
The producer, in this case, mountain mahogany, may be eaten by a first level or primary consumer such as the mule deer. The deer could be fed upon by a coyote which is a secondary consumer.

In most real communities there are so many different possible chains and these are so intertwined, that together they form a community food web.

6

A fallen ponderosa, weathered and gray with death, speaks of continuity and change. A single tree completes its life cycle as organisms of decay break down the organic compounds that make up the plant into inorganic remnants.

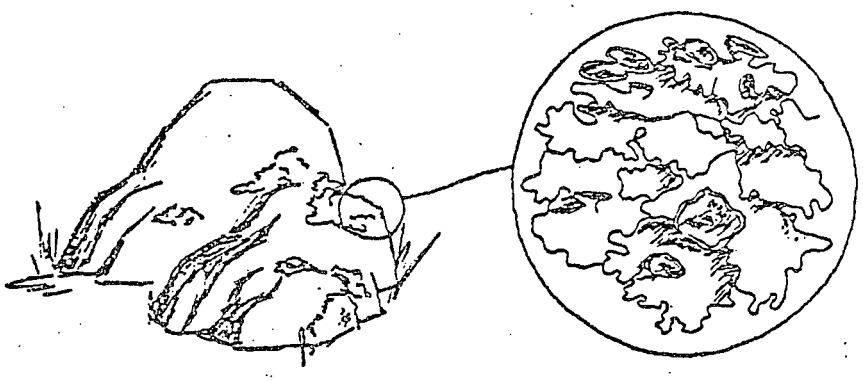
Through respiration and digestion, bacteria and fungi use organic energy not harvested by consumers. They release inorganic nutrients back into the environment. Thus simple substances are <u>recycled</u>--they can be used once again as nourishment for the producers.



7

This mosaic of colored lichens is more than a decorative coat for the rocks. Each plant or animal has a specialized role or function to perform within the ecosystem. This role is called an ecological niche.

As lichens carry out their life processes, they chemically dissolve the surface of the rock. The growing action of the plant roots helps to break the rock into smaller and smaller pieces until they finally become part of the soil. More complex plants begin to grow as lichens build up the soil cover.



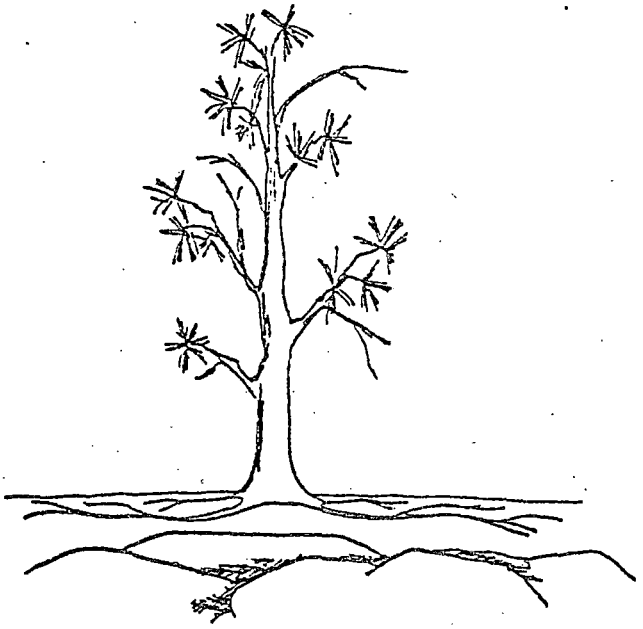
This hot, dry area with only a thin layer of poor soil covering the rocks does not seem conducive to life. However, the structure of the ponderosa pine community is adapted to these conditions. The community and the non-living environment function together as an ecological system or ecosystem. Each influences the other and both are necessary to maintain life as we have it on earth.

9

To know the West is to know its ponderosa pine. Widely distributed, the hardy ponderosa can endure great variations in climate and slope, but it must have some moisture and nutrients to survive and grow.

Because there is only a thin mantle of soil covering the thick layers of rock of this area, the roots must spread out from trees in search of needed water and minerals. Soil depth is a critical factor affecting how well the trees grow in this dry region.

Any factor that tends to slow down potential growth in an ecosystem is said to be a limiting factor.



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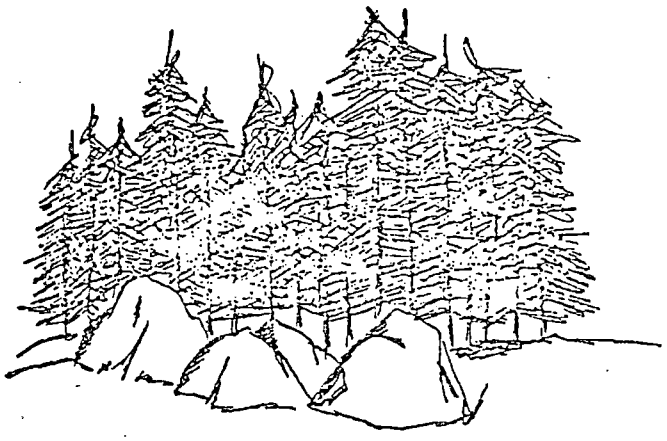


Stunted and weakened, each tree in this stand is engaged in a struggle to obtain life-sustaining sunlight, moisture and nutrients.

Competition occurs when the use of a resource--food, water, space, light--by one individual reduces the availability of the resource for another individual. Because the supply of needed resources does not meet the demand for them, all trees are hampered. The vigor and growth of each ponderosa is diminished as competition increases.

11

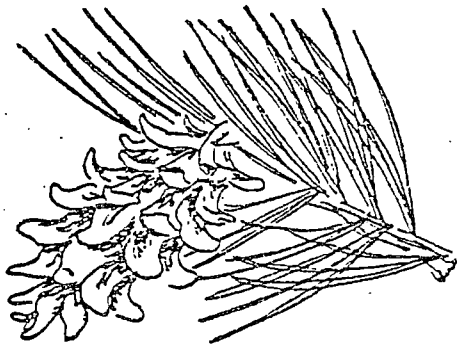
Scattered at the base of the trees are cones--each encasing the potential for many more ponderosa pines. Were the potential realized, the forest would be a mass of impenetrable green. However, very few of these seeds will germinate, survive, and grow.

Porcupines, woodpeckers, deer mice and chipmunks feast on the seeds of this pine. When eaten, the seeds are destroyed in the digestive tract of the animal.

If the seed escapes consumption, it must encounter a favorable combination of heat, light, moisture and soil depth in order to sprout.

The seedling crop is curbed by the browsing of deer and stock grazing. Fire can virtually eliminate young ponderosas from a grove.

Because of these population controls the tree must set forth a large number of seeds in order that a few will survive.



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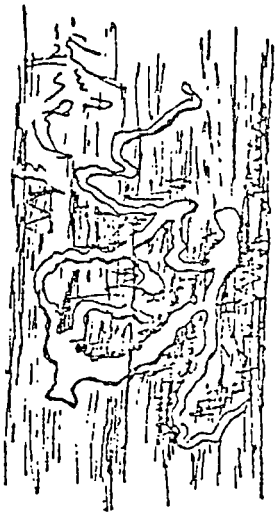


This mighty tree, once a monument of strength and majesty, was killed by an army of small enemies. The larvae of pine bark beetles feed or prey on ponderosa pines.

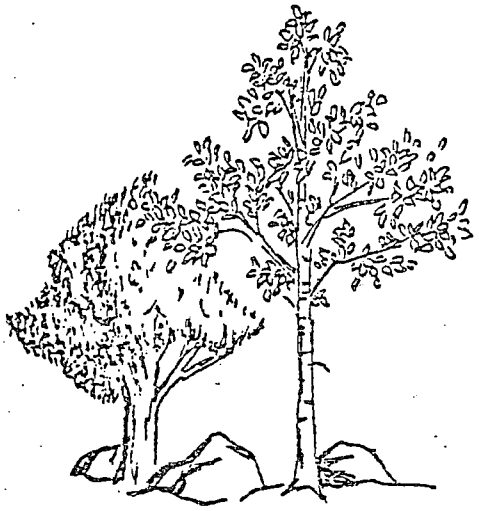
Adult beetles bore through the bark and carve out tunnels in the sapwood. Here they lay their eggs. When the eggs hatch, the larvae begin feeding and burrowing more channels. These tunnels cut the flow of life-giving sap from the roots to the branches of the tree. The tree dies.

Both plant and animal predators depend on the survival of the prey species. The predator-prey relationship is complex. The predator limits and regulates the population of the prey species while maintaining its existence.

13

The bushy dark-green tree in this area is Rocky Mountain juniper. The white-barked tree is quaking aspen.

Neither tree grows abundantly at this particular spot. Juniper prefers warmer, dryer conditions. The aspen needs more moisture. The two species are not doing well because their growth conditions are poor. The carrying capacity for the plants is low. This area could not support many healthy juniper and aspen for long. However, the environment for ponderosa pines is good and many healthy trees grow here. Thus, the carrying capacity for this species of pine is fairly high.



14

Of all the western pines, the ponderosa is most possessed by sunlight. When caressing summer winds whisper through the grove, flashes of light streak and stab its burnished needles.

Without sunlight, life cannot exist. The ultimate source of all energy is the sun. Only green plants capture and use the sun's energy directly. By feeding on plants or other animals that eat plants, species obtain energy from the sun indirectly.

Thus, energy is transferred along a one-way path up through the food chain. Each time there is a transfer, energy is lost. It can never be recovered. Therefore, animals at the far end of the food chain (those eating other animals) must consume proportionately more food than animals that eat plants in order to meet their energy requirements.

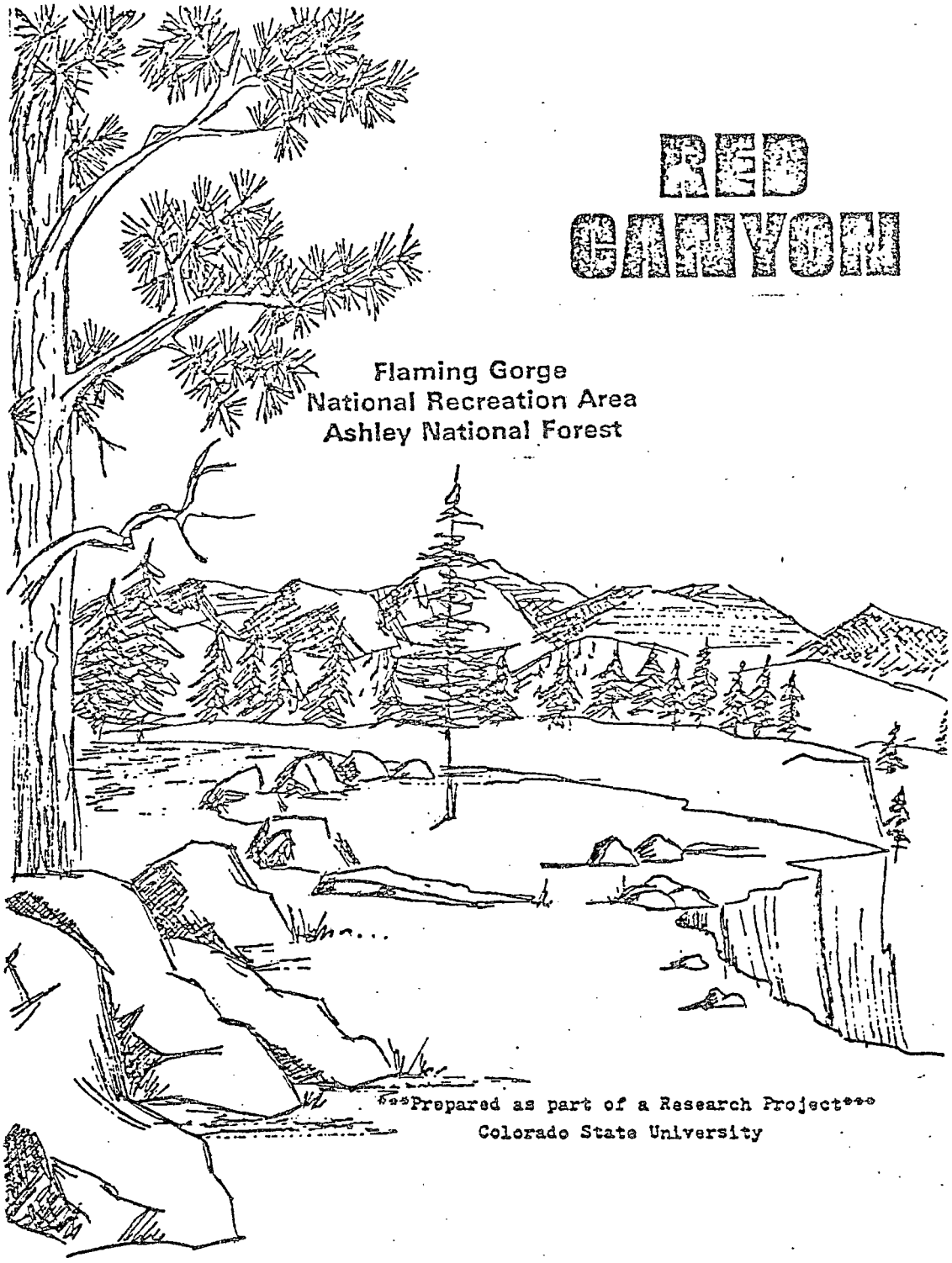
15

The yellow-bellied marmot, often called a rock chuck, makes his home in the hole beneath this rock. Sporting a golden-brown coat with a yellow belly and bushy tail, this animal lives in a wide variety of areas, but often chooses rocky spots to make a permanent home.

No other animal in the community fills the same role or niche as the marmot. Two species cannot co-exist if they need the same limited resources for survival. One of the species will become extinct. This is the <u>principle of competitive exclusion</u>.

APPENDIX C

TRAIL GUIDE WITH ANALOGIES



RED CANYON

Flaming Gorge
National Recreation Area
Ashley National Forest

Prepared as part of a Research Project
Colorado State University

7

The ponderosa pine, aromatic and sparkling, dominates this community. Dusty-green clumps of bitterbrush can be found below it, providing an important winter food source for mule deer.

Many people who look at this forest see only trees. However, the forest community is a complex association of interacting plant and animal populations. The species in this community demand similar resources. The amount and type of resources such as food, water and living space will determine which forms of life will flourish and which will perish in any region.

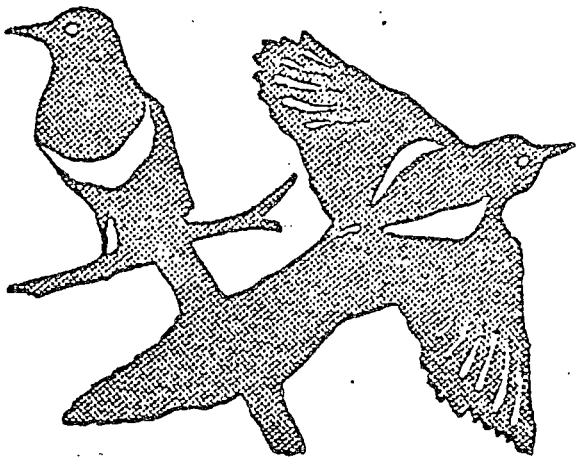
Areas with different types of resources will support different types of communities. You could not expect to find the ponderosa growing well in the lush Eastern deciduous forest. Similarly, sugar maples would find this dry region unlivable.

Human communities are differentiated in the same way. People tend to live in places according to personal demands for social contacts, cultural opportunities or different services.

2

Stop and listen. You may hear the songs, chattering or pecking of different kinds of birds. Several species make their homes in the mountain forest. The place where an organism lives is called its habitat. A habitat includes all the features of the environment where a plant or animal lives.

Man's habitat includes the area where he lives, shops, works and plays.



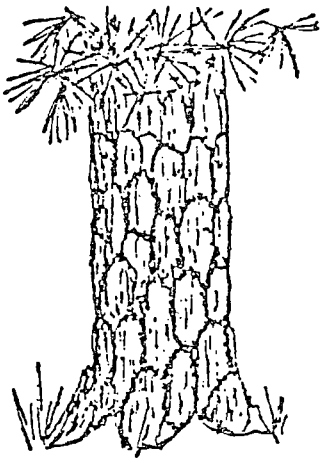
3

Although the wafting fragrance and proud chanty of the pines fill the air, there are many more subtle sounds and smells in this community.

Diversity ensures stability. If this community were composed of nothing but ponderosas, what would happen if all became diseased and died? The forest would become a barren wasteland. The community is stable because other plants reproduce and live here under similar conditions to the pine's. Thus, if all the ponderosa pines were eliminated, these other plants could live on the land where the ponderosa once stood. The community could not be easily destroyed.

This situation holds in the human environment as well. Human communities where people produce many different products have a more stable economy than those where all people produce the same thing.

4



The ponderosa reigns in this small mountain kingdom. The strong trunk and limber branches of this rugged pine make it seem arrogant and independent. However, it is affected by smaller forms of life in the grove, just as they are influenced by this pine.

All living things affect all other living things. The community is made vital by complex interactions. These interactions directly or indirectly tie all its members together in a vast web of life.

When insects destroy a ponderosa pine, its death affects the surrounding life. As the tree is stripped of its foliage more sunlight reaches the forest floor. Different organisms favoring sunlight can now grow there. Those that favored the shade of the pine boughs may now find survival difficult.

Man is also in a system where the actions of individuals can have an impact on the lives of many people.

5

Mule deer have "highlined" this mountain mahogany by eating everything as high as they could reach. Any new growth that takes place is on the top branches, inaccessible to the browsing animals. Because of this "highlining", this mountain mahogany is out of the deer's food chain.

A food chain is simply a series of plants and animals which are eating and being eaten. No matter how long the chain may be it begins with green plants or producers and ends with decomposers, the organisms of decay. The links between producers and decomposers depend on the community.

The producer, in this case, mountain mahogany, may be eaten by a first level or primary consumer such as the mule deer. The deer could be fed upon by a coyote which is a secondary consumer.

In most real communities there are so many different possible chains and these are so intertwined, that together they form a community food web.

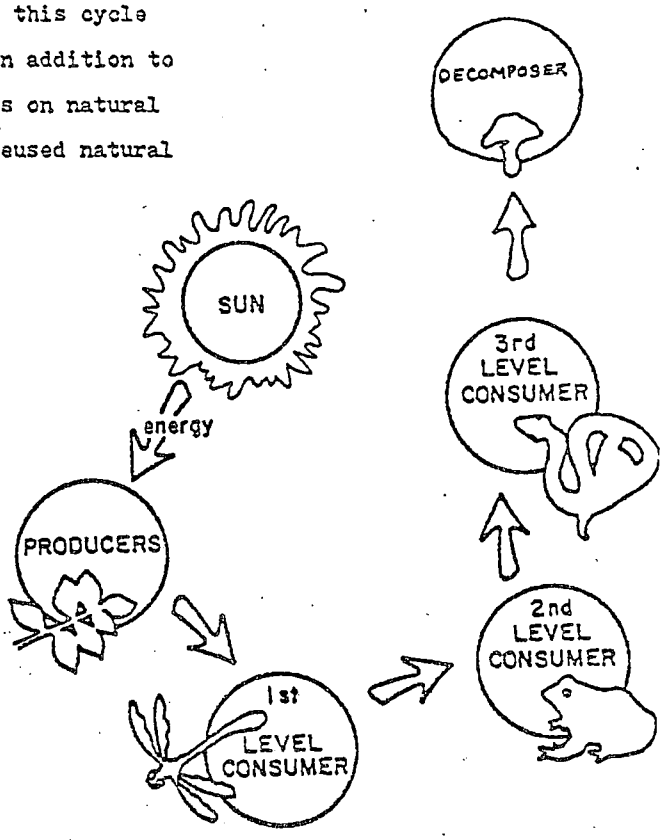
Man is a part of a system of food chains as well. As he manipulates the environment, safeguards must be provided to protect linkages in the chains he influences.

6

A fallen ponderosa, weathered and gray with death, speaks of continuity and change. A single tree completes its life cycle as organisms of decay break down the organic compounds that make up the plant into inorganic remnants.

Through respiration and digestion, bacteria and fungi use organic energy not harvested by consumers. They release inorganic nutrients back into the environment. Thus simple substances are recycled--they can be used once again as nourishment for the producers.

Man often disrupts this cycle of resource renewal. In addition to making extensive demands on natural resources, he has not reused natural wastes.



7

This mosaic of colored lichens is more than a decorative coat for the rocks. Each plant or animal has a specialized role or function to perform within the ecosystem. This role is called an ecological niche.

As lichens carry out their life processes, they chemically dissolve the surface of the rock. The growing action of the plant roots helps to break the rock into smaller and smaller pieces until they finally become part of the soil. More complex plants begin to grow as lichens build up the soil cover.

In the human environment we recognize many different occupations or niches, each having a definite place in the community.

This hot, dry area with only a thin layer of poor soil covering the rocks does not seem conducive to life. However, the structure of the ponderosa pine community is adapted to these conditions. The community and the non-living environment function together as an ecological system or ecosystem. Each influences the other and both are necessary to maintain life as we have it on earth.

Man also functions in an ecosystem. For example, when he changes the non-living environment by discharging chemical pollutants into the atmosphere, he influences the life patterns of plants and animals in the community.

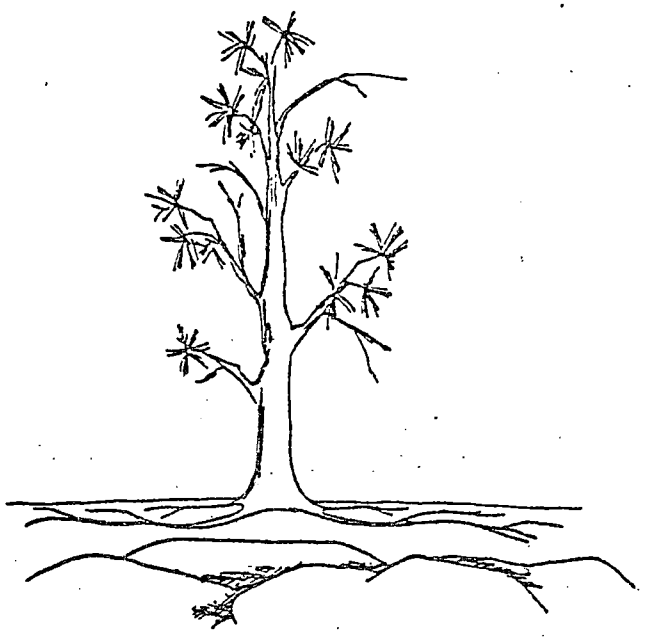
9

To know the West is to know its ponderosa pine. Widely distributed, the hardy ponderosa can endure great variations in climate and slope, but it must have some moisture and nutrients to survive and grow.

Because there is only a thin mantle of soil covering the thick layers of rock of this area, the roots must spread out from trees in search of needed water and minerals. Soil depth is a critical factor affecting how well the trees grow in this dry region.

Any factor that tends to slow down potential growth in an ecosystem is said to be a limiting factor.

There are also limiting factors that affect the human environment. Water pollution and smog, when really bad, can limit human population growth and density.



10

Stunted and weakened, each tree in this stand is engaged in a struggle to obtain life-sustaining sunlight, moisture and nutrients.

Competition occurs when the use of a resource--food, water, space, light--by one individual reduces the availability of the resource for another individual. Because the supply of needed resources does not meet the demand for them, all trees are hampered. The vigor and growth of each ponderosa is diminished as competition increases.

In the human community, conflicts between people intensify when there are not enough resources to go around.

11

Scattered at the base of the trees are cones--each encasing the potential for many more ponderosa pines. Were the potential realized, the forest would be a mass of impenetrable green. However, very few of these seeds will germinate, survive, and grow.

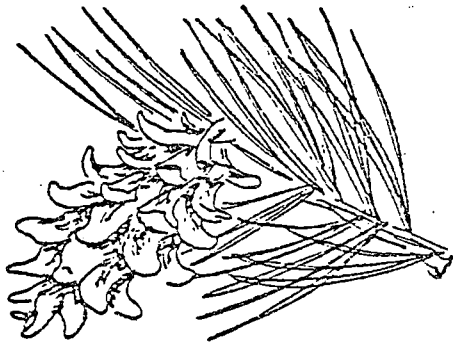
Porcupines, woodpeckers, deer mice and chipmunks feast on the seeds of this pine. When eaten, the seeds are destroyed in the digestive tract of the animal.

If the seed escapes consumption, it must encounter a favorable combination of heat, light, moisture and soil depth in order to sprout.

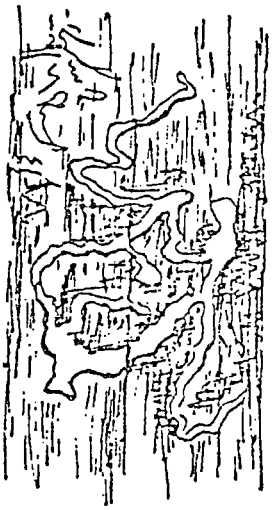
The seedling crop is curbed by the browsing of deer and stock grazing. Fire can virtually eliminate young ponderosas from a grove.

Because of these population controls the tree must set forth a large number of seeds in order that a few will survive.

The world cannot support an unlimited number of people. Forces such as natural disasters, war, disease, and famine keep human population levels in check. Man also can take positive steps to limit his population.



12



This mighty tree, once a monument of strength and majesty, was killed by an army of tiny enemies. The larvae of pine bark beetles feed or prey on ponderosa pines.

Adult beetles bore through the bark and carve out tunnels in the sapwood. Here they lay their eggs. When the eggs hatch, the larvae begin feeding and burrowing more channels. These tunnels cut the flow of life-giving sap from the roots to the branches of the tree. The tree dies.

Both plant and animal predators depend on the survival of the prey species. The predator-prey relationship is complex. The predator limits and regulates the population of the prey species while maintaining its existence.

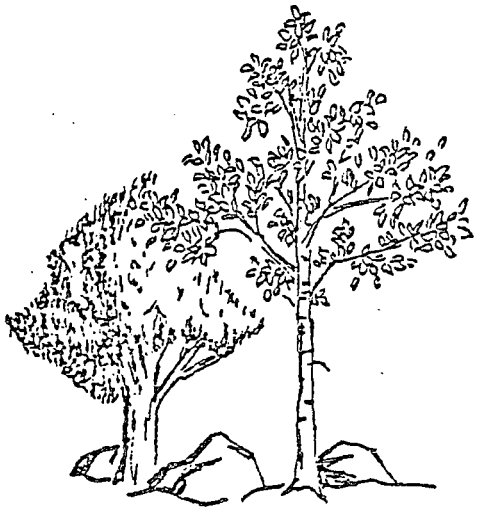
Man is the greatest of all predators. He feeds on a wide variety of plant and animal species and often kills far beyond his needs. Thus he has the power to upset the natural balance of the predator-prey scheme.

13

The bushy dark-green tree in this area is Rocky Mountain juniper. The white-barked tree is quaking aspen.

Neither tree grows abundantly at this particular spot. Juniper prefers warmer, dryer conditions. The aspen needs more moisture. The two species are not doing well because their growth conditions are poor. The carrying capacity for the plants is low. This area could not support many healthy juniper and aspen for long. However, the environment for ponderosa pines is good and many healthy trees grow here. Thus, the carrying capacity for this species of pine is fairly high.

The carrying capacity concept also applies to the human environment. As people are crowded into an area of limited resources their numbers reach a capacity limit. Their physical and mental well-being often deteriorate as this human carrying capacity is exceeded.



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Thus, energy is transferred along a one-way path up through the food chain. Each time there is a transfer, energy is lost. It can never be recovered. Therefore, animals at the far end of the food chain (those eating other animals) must consume proportionately more food than animals that eat plants in order to meet their energy requirements.

Unlike other resources, the energy resource is lost once it is used by man. The "energy crisis" is a glaring reminder that we must use our limited resources more efficiently.

15

The yellow-bellied marmot, often called a rock chuck, makes his home in the hole beneath this rock. Sporting a golden-brown coat with a yellow belly and bushy tail, this animal lives in a wide variety of areas, but often chooses rocky spots to make a permanent home.

No other animal in the community fills the same role or niche as the marmot. Two species cannot co-exist if they need the same limited resources for survival. One of the species will become extinct. This is the principle of competitive exclusion.

This concept works in the human community. If two butchers come to live in a community where there are only enough customers to support one shop, the less favored business will lose money until it can no longer survive economically.

APPENDIX D

ANALYSIS OF VARIANCE

(Testscore by each Environmental and Respondent Variable)

ANALYSIS OF VARIANCE

Analysis of Variance for Red Canyon self-guided trail study (testscore by each environmental and respondent variable); Flaming Gorge N.R.A., summer, 1975.

Environmental/ respondent variable	Analogy group F ratio	No analogy group F ratio	Control F ratio
Walked trail before	0.12, 1df	3.46, 1df	0.02, 1df
Visited the N.R.A. before	0.20, 1df	5.20, 1df	0.01, 1df
Read message at each stop	0.49, 2df	0.42, 2df	--------
Education level	13.04,**3df	14.94,**3df	11.78,**3df
Age	7.74,**4df	5.16,**4df	4.78,**3df
Sex	4.43,* 1df	0.31, 1df	0.02, 1df
Population of residence	2.78,* 5df	1.65, 5df	2.90, 5df
Understanding of ecological concepts	8.20,**4df	2.13, 4df	1.90, 4df
Concern about environmental problems	3.01,* 4df	2.80, 4df	1.57, 4df

* $p \leq 0.05$

**$p \leq 0.01$

APPENDIX E

MEAN SEPARATION

(Testscore by Treatment)

MEAN SEPARATION

(Differences among mean testscores according to treatment groups)

Tukey's HSD mean separation test following analysis of variance for Red Canyon self-guided trail study (testscore by treatment group); Flaming Gorge N.R.A., summer, 1975.

Group	Testscore	Analogy group	No analogy	Control
Analogy group	8.97	---	1.78*	1.90*
No analogy group	7.19		---	0.12
Control group	7.07			---

*$p \leq 0.05$

APPENDIX F

MEAN SEPARATION

(Testscore by Age)

MEAN SEPARATION

Tukey's HSD mean separation test following analysis of variance for Red Canyon self-guided trail study (testscore by age group); Flaming Gorge N.R.A., summer, 1975.

	Testscore	Group 1	Group 2	Group 3	Group 4	Group 5
(differences among mean testscores according to age groups[a] across all treatment groups)						
Group 1	5.79	----	1.36	3.92*	2.69*	1.67
Group 2	7.15		----	2.66*	1.33	0.31
Group 3	9.71			----	1.23	1.25
Group 4	8.48				----	1.02
Group 5	7.46					----
(differences among mean testscores according to age groups--analogy group)						
Group 1	6.87	----	2.63	5.53*	2.18	1.13
Group 2	9.50		----	2.90	0.45	1.50
Group 3	12.40			----	3.35*	4.50*
Group 4	9.05				----	1.05
Group 5	8.00					----
(differences among mean testscores according to age groups--no analogy group)						
Group 1	5.28	----	0.72	3.18*	2.91	3.12
Group 2	6.00		----	2.46	2.37	2.40
Group 3	8.46			----	0.09	0.06
Group 4	8.37				----	0.03
Group 5	8.40					----
(differences among mean testscores according to age groups--control)						
Group 1	5.55	----	1.45	2.85	2.32	0.55
Group 2	7.00		----	1.40	0.87	2.00
Group 3	8.40			----	1.53	3.40
Group 4	7.87				----	2.87
Group 5	5.00					----

*$p \leq 0.05$

[a]Ages were grouped into the following categories: Group 1--14 years and under; Group 2--16-20 years; Group 3--21-30 years; Group 4--31-60 years; and Group 5--over 60 years in age.

APPENDIX G

MEAN SEPARATION

(Testscore by Education)

MEAN SEPARATION

Tukey's HSD mean separation test following analysis of variance for Red Canyon self-guided trail study (testscore by education level[a]); Flaming Gorge N.R.A, summer, 1975.

	Testscore	Group 1	Group 2	Group 3	Group 4
(differences among mean testscores according to education level across all treatment groups)					
Group 1	5.87	----	0.91	3.38*	4.66*
Group 2	6.78		----	2.47*	3.75*
Group 3	9.25			----	1.28
Group 4	10.53				----
(differences among mean testscores according to education level--analogy group)					
Group 1	6.65	----	1.45	3.62*	4.99*
Group 2	8.10		----	2.17*	3.54*
Group 3	10.27			----	1.37
Group 4	11.64				----
(differences among mean testscores according to education level--no analogy group)					
Group 1	5.68	----	0.13	3.32*	4.49*
Group 2	5.55		----	3.45*	4.52*
Group 3	9.00			----	1.17
Group 4	10.17				----
(differences among mean testscores according to education level--control group)					
Group 1	5.21	----	1.44	3.01*	4.46*
Group 2	6.65		----	1.57*	3.02*
Group 3	8.22			----	1.45
Group 4	9.67				----

*p = 0.05

[a]Education levels were grouped: Group 1--8th grade or less; Group 2--9th-12th grade; Group 3--13-16 years; Group 4--17-20 years of education.

APPENDIX H

MEAN SEPARATION

(Testscore by Treatment Following Analysis of Covariance)

MEAN SEPARATION

(Differences among mean testscores according to treatment groups)

Tukey's HSD mean separation test following analysis of covariance for Red Canyon self-guided trail study (testscore by treatment group with covariates education level and age); Flaming Gorge N.R.A., summer, 1975.

Group	Testscore	Analogy group	No analogy	Control
Analogy group	8.81	---	1.54*	1.66*
No analogy group	7.27		---	0.12
Control group	7.15			---

*$p \leq 0.05$